Module 2: Core Concepts in Health Economic Evaluation
Participant Workbook

Module two provides an introduction to some of the core concepts used in health economic evaluation.
The module has four units:

- Unit 1: Analysis of costs
- Unit 2: Analysis of benefits
- Unit 3: Synthesis of costs and benefits
- Unit 4: Uncertainty

Upon successful completion of the course, you will have covered the core concepts of health economic evaluation.

Unit 1

- Define the concept of perspective
- Identify the potential sources of resource use
- Identify different types of costs

- Describe approaches for the analysis of resource use, prices, and productivity loss
- Describe time horizons and discounting

Unit 2

- Identify different types of benefit measures
- Describe and define the QALY
- Outline three approaches to valuing health states
- Discuss how time preferences are accounted for in the valuation of health benefit

Unit 3

- Describe and distinguish partial and full economic evaluations
- Describe the definition and purpose of: WTP, ICER, NB, Dominance, and the Cost-Effectiveness Plane

Unit 4

- Identify sources of uncertainty
- Outline a number of approaches to describing uncertainty
- Identify strategies for addressing uncertainty

UNITS

Uncertainty

Analysis of Costs

Welcome to the first unit of Module Two, which is Analysis of Costs.

Unit Objectives

By the end of this unit, you should be able to meet the following objectives:

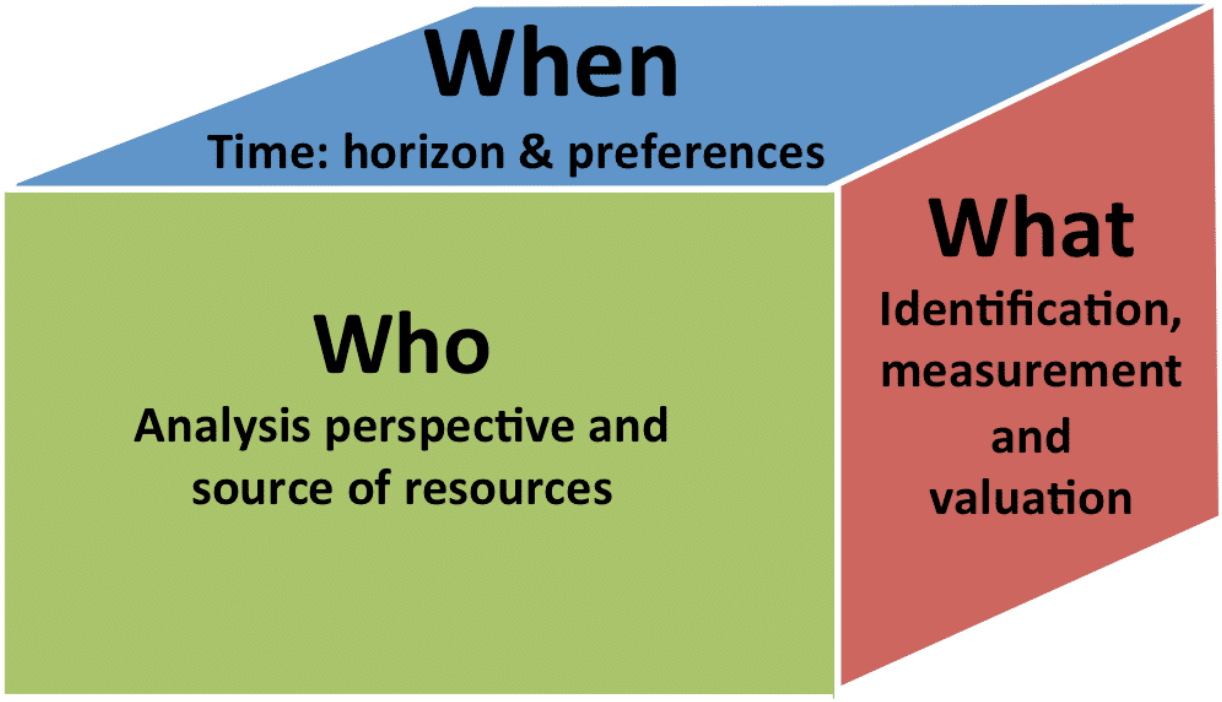
- Introduce the concept of perspective
- Identify the potential sources of resource use
- Identify the types of costs
- Outline approaches for the analysis of resource use, prices and productivity loss
- Discuss time horizons and introduce the concept of discounting

Unit Topics

The topics that will be covered in this unit are the three dimensions of the analysis of costs:

1. Analysis perspective and sources of resources
2. Identification, measurement, and valuation of costs
3. Time horizon and time preferences

3 Dimensions of cost analysis



Video Presentation

Here's the video presentation for this unit:

Video presentation notes:

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1. Analysis Perspective and Sources of Resources

One of the first and most important decisions we must make before conducting our analysis of costs is whose costs do we count? Or to use the technical term, what is the *perspective* on costs adopted by the analysis?

There are multiple different sources of potential funding for healthcare and other costs associated with health problems—the health and social care system, health insurers, patients, patient's families, and the wider economy—so the choice about whose costs we choose to count may make a big difference to our results.

For example, if we only look at patient costs we might get a very different result to that we would get if looking only at the costs borne by the hospital treating the patient.

Here are some of the perspectives we can adopt. Click each one to learn more.

Patient/Patient and Family and Carer	Only count costs borne by patient or by patient and their family and carers
Healthcare organization/unit	Only count costs borne by specified organization or department
	Count only costs borne by the entire health and social

Health & social care system	care system, wherever they arise. For example, we would still count costs arising in primary care such as GP visits even if
Health & social care system and patient	We count both patient and health and social care system costs
Third-party payer	Count only costs borne by specified third parties, e.g. health insurer

Societal	Everyone's cost is counted, including productivity loss to the wider economy

2. Identi cation, Measurement and Valuation of Costs

Having decided on perspective, the next step is the identification, measurement and valuation of costs, which principally involves identifying:

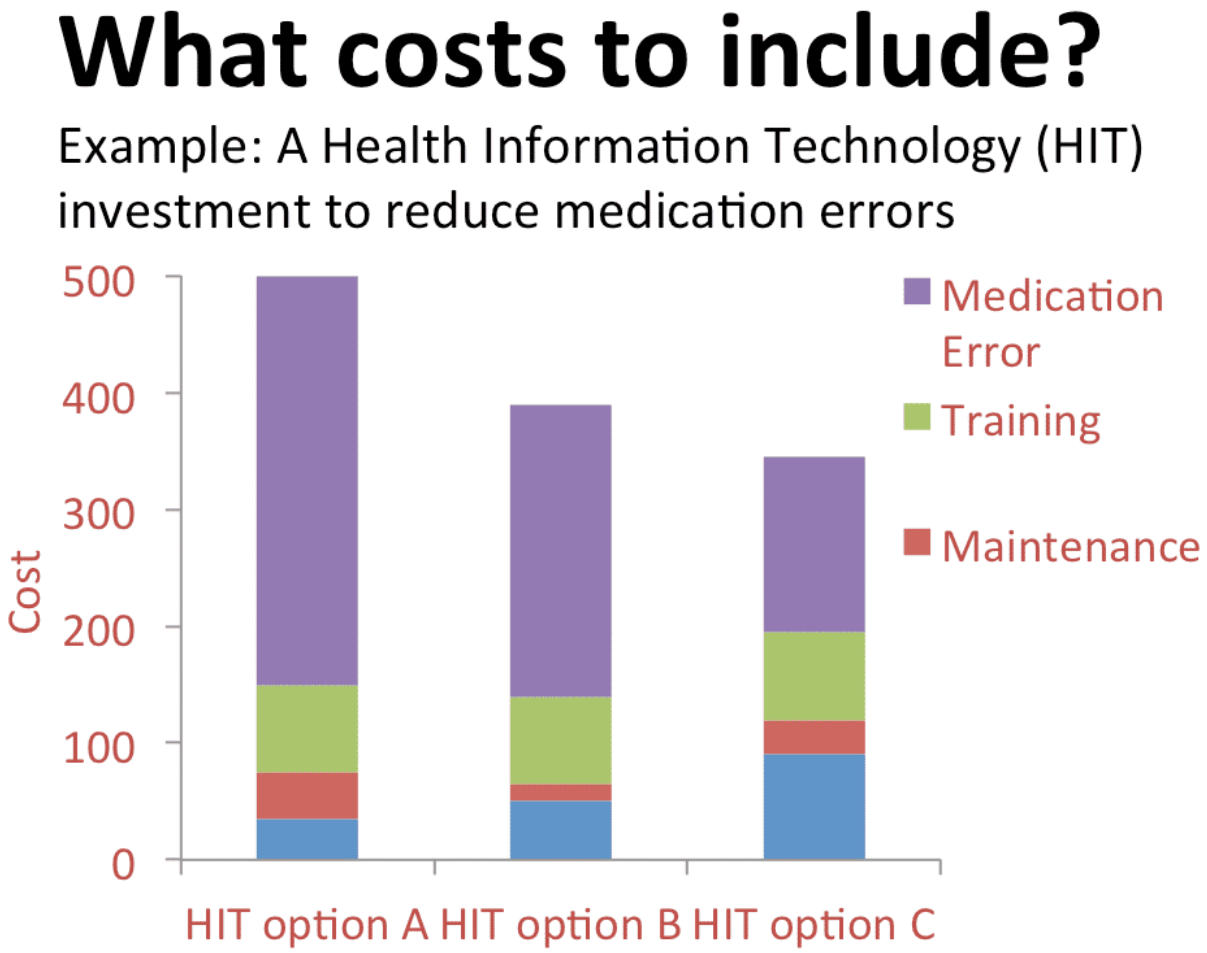
- which costs to include and which to exclude from the analysis
- types of cost
- the level of resource use and appropriate unit costs for each resource
- the appropriate approach to the valuation of productivity lost

2.1 Identifying which Costs to Include and which to Exclude

Having identified the perspective (whose costs to count) the next step is to determine what costs to count.

As can be seen from the graphic outlining the cost profile of a hypothetical set of three health information technology investment options, the decision as to which type of costs you count may significantly influence your results.

If you only examined the acquisition cost for the technology—the blue component of each cost bar—then you would come to a very different conclusion about cost than if you also decide to count the costs of maintenance, training, and medication errors that arise from or are addressed by the investment. We should count all costs that might affect our results, so long as they are consistent with our perspective (i.e. costs that are borne by the entities included in our perspective) and our timeframe (i.e. costs that occur in the time period that we are examining).



What costs to include?

However, because in health economic evaluation we are concerned with determining **differences** in cost and differences in effect between at least two options, **if**

there are some items of cost that are going to be the same in all options then we do not need to count them.

Similarly, if a category of costs are going to be too small to meaningfully influence results but would entail a lot of time and effort to measure accurately, then we may choose to exclude those as well.

2.2 Types of Costs

There are a number of different ways we can categorize different types of cost. One of the most common divisions is fixed costs, variable costs, and total cost. Click each one to learn more.

Fixed Costs

- Fixed Costs: Costs that do not vary with quantity produced/service provided (at least in short run). An example would be the rent on a building.

Variable Costs:

- Variable Costs: Costs that vary depending on quantity produced/service provided. For example, costs that depend on the amount of patients who are provided a service (e.g. the amount of medication ordered) will be variable costs.

Total Cost

- Total Cost: All costs = (Fixed Costs + Variable Costs).

Another way of describing costs is to distinguish between **Average Cost and Marginal Cost**.

- Average Cost = Total Costs divided by the Quantity Produced.
- Marginal Cost (cost of producing an extra unit of the product or service) = Change in Total Costs divided by Change in Quantity.

A third way of describing costs is to talk about **Direct Costs** and **Indirect Costs**.

	Medical Costs	Nonmedical Costs
Direct (directly related to the disease and its management)	Consultations, drugs, hospital admissions, tests, imaging…	Transportation Informal carers
Indirect	Costs of prolonged life	Lost productivity: sick leave, presenteeism, premature death

Drummond M, et al. *Methods for the Economic Evaluation of Health Care Programmes*, 3rd ed., New York: Oxford University Press; 2005.

- When looking at **medical or health care costs,** Direct Costs are things like the medications, devices, and inpatient stays, whereas Indirect Costs in the medical category will be things like the cost of providing care as a result of prolonged life.
- When looking at **non medical costs or non healthcare costs**, Direct Costs would be patient's transportation costs to and from consultations or the cost of childcare that they must bear in order to

> get to those consultations (assuming that patient costs are included in the analysis perspective), whereas examples of Indirect Costs would be productivity losses associated with patient illness (assuming a societal perspective is adopted).

2.3 Resource Use and Prices

One of the important things to stress in how to approach costing in health economic evaluation is that it is preferable to decompose cost into two components:

- **Resource use**
- **Prices**

What this means is, instead of simply reporting a top-level line item of a thousand dollars for a cost item, we should break this down to make it clear that the cost item was comprised of five units of this resource used (e.g. five clinical consultations) at a price of two hundred dollars for each consultation. Providing this extra detail improves the transparency of the analysis and also enables us to explore distinct scenarios in more depth (changes in price, changes in demand).

Measurement of Resource Use

When we are measuring resource use we use natural units, for example hours, days, five blister packs of medication. Our measurement of resource use might be from one of a number of potential sources:

- [ ] Administrative or medical records
- [ ] A Clinical Trial or observational study
- [ ] An assumption based on expert opinion

Prices

Having identified how many units of particular resources have been consumed, the next step is to price it using unit prices (i.e. the price per unit).

Unit prices in economic evaluations are based on the concept of opportunity cost. Opportunity cost is an economic concept which means the best alternative use of a specified resource. When goods and services are traded in a market that can be quite easy to determine—the market price provides the opportunity cost. However, many items in healthcare are not traded in dynamic marketplaces, so we may need to find alternatives to determining the appropriate unit price. Resources like lists of reference costs, which are often published by the government or by academic units, can be used to give us an appropriate unit cost for a particular procedure or a particular service.

We also must adjust for time when valuing resource use, as prices in one year will not necessarily be the same as in another. When adjusting for how healthcare prices change over time, we use the relevant national healthcare inflation index (not the Consumer Price Index).

If we need to convert prices between countries, we use Purchasing Power Parity instead of a published exchange rate. Purchasing Power Parity measures the ability of a particular unit of currency to purchase equivalent goods and services as in another country's unit of currency, which is a much better measure than an exchange rate. As with inflation figures, where possible, we should identify the Purchasing Power Parity measure that is specific to healthcare. The Self-Assessment exercise will outline some of these steps in more detail.

Calculation

Once you have performed any necessary adjustments to unit prices, you can apply those unit prices to each resource item:

- Cost per item = Resources used x Unit Price

2.4 Valuation of Productivity Loss

Depending on the perspective chosen and the health condition that is being examined, you may need to value productivity loss arising from the time that patients and their family members/carers were unable to participate in work arising from their illness and its treatment.

One of the most important choices to make in approaching the valuation of productivity loss is between adopting a human capital or a friction cost approach to valuation:

- A human capital approach values all the potential time for participation in work lost by an individual due to their health state (i.e. the amount of time they would have been able to be at work if it were not for ill health)
- A friction cost approach just values the potential work time lost to the employer (i.e. the time between the employee's initial absence due to ill health until a replacement employee is hired)

National best practice guidelines frequently recommend one of the above methods in preference to another. You should consult the guidelines relevant to your context before making a decision.

3. Time Horizon and Time Preferences

In addition to making adjustments to prices to account how they change over time (discussed in the section on identification, measurement, and valuation of costs), there are two other aspects of time that have to be accounted for in your analysis. These are:

- time horizon
- time preferences

3.1 Time Horizon

The decision about time horizon relates to the study as a whole and will therefore be made before you start analyzing costs. However, when making this decision you should be thinking

ahead to the potential implications of your choice of time horizon for the analysis of costs (and of benefits). There are pros and cons of short and longer time horizons.

It is easier to measure costs and to measure them accurately if you are only counting over a relative short time. However, the downside of shorter time horizons is that we might miss out on important information relating to downstream costs that don't become apparent until maybe one year or two years after a particular decision has been made.

On the flip side, long-term costs may be more appropriate for those sort of projects with enduring or delayed cost and benefit impacts, but collecting this information may involve more expense and it may be difficult to actually acquire reliable data over the longer time.

3.2 Time Preferences (Introduction to Discounting)

Generally speaking, we prefer pleasure today and pain tomorrow. This feature of human nature is something we have got to factor into our analysis of costs on the basis that:

- a $100 cost today is less preferable to a $100 cost (at constant prices) that we must pay in ten years time

If the study time horizon extends beyond one year, we must **discount** the future costs and benefits to account for the value of time preferences. We use a **discount rate** to adjust for time preferences between years. The economic evaluation guidelines for your country or region will frequently specify a discount rate for costs, which tends to be somewhere between 0-5% per year.

We have a choice of two main discounting formulae to use:

- If we are discounting a lump sum (i.e. one payment at one time point) we use:
    - PV=FV/(1+i)n
- If we are discounting a stream of payments (i.e. a series of payments over time) then we use:
    - PV=FV1/(1+i)1 + FV2/(1+i)2 + ….+FVn/(1+i)n
- In both cases, PV= Present Value, FV= Future Value, i= discount rate, n=year

Undertake the analysis of costs self-assessment exercise for an opportunity to apply these formulae in practice. Note, when using the above formulae the current year is year zero.

Exercises and Further Reading

Self-assessment and critical review exercises

After reviewing this module's content:

1. Undertake the following critical review task:

- Review the descriptions of how costs have been examined in the economic evaluation sample papers assigned to you (most likely to be found as part of the Methods section of each paper). See if you can identify how resource use was established, how prices were determined, and what approach to discounting has been used.

Health Economics Sample Economic Evaluation Paper 1.pdf
320.2 KB

Health Economics Sample Economic Evaluation Paper 2.pdf
346.6 KB

2. Undertake the following self-assessment task:

- **Self-Assessment Exercise 1: Analysis of Costs**

In this self-assessment exercise, you will undertake the following tasks:

1. Identify resource use
2. Identify unit costs by looking up reference costs
3. Update all unit costs to common price year
4. Calculate total undiscounted costs
5. Discount costs
6. Calculate total costs

All this tasks are to be completed using the Excel template below. You can complete your work by going through the worksheets labelled Q1 to Q5 in order, reviewing the task instructions on each worksheet and filling in the green cells. As you complete each worksheet's set of tasks, the information on subsequent worksheets will update. In order to complete some of the green cells you will need to look up items in the reference costs book included below.

When complete you can compare your results to the sample answers provided as the end of the exercise.

Self Assessment Exercise 1 - Analysis of Costs.xlsx
52.5 KB

Reference Costs UK 2011 - Use for Self-Assessment Exercise.

Please click here to download.

Reference Costs UK 2012 - Use for Self-Assessment Exercise.

Please click here to download.

Reference Costs UK 2013 - Use for Self-Assessment Exercise.

Please click here to download.

Reference Costs UK 2014 - Use for Self-Assessment Exercise.

Please click here to download.

Solutions Self Assessment Exercise 1 - Analysis of Costs.xlsx
52.3 KB

References and Further Optional Reading

If you would like to do further optional reading about the topic, you may wish to consider the following resources:

- B Parkinson and R De Abreu Lourenco. "Discounting in Economic Evaluations in Health Care: A brief review." Cancer Research Economics Support Team, 2015.
- S Simoens, "Health Economic Assessment: A Methodological Primer." Int. J. Environ. Res. Public Health 2009.

Note on links: If you find that a hyperlink used in this module is out of date, please notify us at cdneducationlead@leadingedgegroup.com. You may also be able to find an out of date web resource by searching for the expired URL at http://archive.org/web/web.php.

Analysis of Bene ts

Welcome to the Unit Two of Module Two, which is: Analysis of Benefits

Unit Objectives

By the end of this unit, you should be able to meet the following objectives:

- Identify different types of benefit measure and outline how they are measured
- Introduce the QALY
- Outline three approaches to valuing health states
- Discuss time preferences

Unit Topics

The topics that will be covered in this unit are the three dimensions of the analysis of benefits:

1. Analysis perspective: who benefits and who values benefits

2. Identification, measurement and valuation of benefits

- Process, intermediate and final outcomes
- Use and valuation of QALYs
- Valuing health states

3. Time horizon and time preferences

- Discounting

Video Presentation

Here's the video presentation for this unit:

Video presentation notes:

1. Analysis Perspective

As with the analysis of costs, we need to decide the perspective that we are adopting for the analysis of benefits. This essentially boils down to two components:

- [ ] Whose benefits do we count?
- [ ] Who values those benefits?

Whose benefits do we count?

Generally, when looking at costs we tend to be concerned with ensuring our perspective encompasses the healthcare organization or the health and social care system or society as a whole. Benefits, by in large, are a little different.

In general, we tend to be principally concerned with patients (and potentially their families/carers as well) as the beneficiary, measuring benefits such as health outcomes or some other utility that is derived from healthcare (e.g. service satisfaction). There are exceptions to this general rule, for example when we are principally concerned with outcomes in clinical staff (e.g. knowledge and skills or morale/staff satisfaction). But in most instances we are likely to be concerned with the patient as the beneficiary and focus on measuring the health and non-health benefits that they receive.

Who values those benefits?

Although a benefit may accrue to the patient, there remains a question of who gets to value that benefit. For example, we could ask:

- [ ] Patients
- [ ] Clinicians
- [ ] Society

There are pros and cons to each approach.

Obviously, patients are going to be more knowledgeable about the reality of living with their health condition, but there is also evidence to suggest that after a period of adapting to a new

health state, patients may undervalue the impairment that a health condition places upon them compared to how members of society without the health condition weight that impairment.

Clinicians have the advantage of having relevant expertise while also potentially being able to provide a more objective assessment than those experiencing the health state.

The advantage of asking a representative sample of members of society for their valuation of benefits is that normally it is society as a whole that pays for healthcare, so it is appropriate that they should be the ones valuing the benefits. This is the reason that the societal perspective is generally preferred for the valuation of benefits in healthcare interventions that are likely to be principally publicly funded.

2. Identi cation, Measurement, and Valuation of Bene ts

Having decided on perspective, the next step is the identification, measurement, and valuation of benefits. To undertake these tasks, it is necessary to understand:

- [ ] Process and outcome measures
- [ ] Condition specific and generic health benefit measures
- [ ] QALYs
- [ ] Valuing health states

2.1 Process and Outcome Measures

One of the divisions that we can make between types of benefit measures are between process and outcome measures.

Process measures tend to be measures of how much of an activity gets done and how well it gets done. Examples of process measures include the number of procedures in a unit of time or waiting times for procedures/consultations.

Outcome measures address the impact of an intervention on the intended beneficiaries. We can measure final or intermediate outcomes. Click each to learn more.

Final outcomes

Final outcomes relate to the end point or ultimate objective of an intervention. For example, if the principal goal of an intervention is to prolong life, the outcome measure might be life years gained.

Intermediate outcomes

Intermediate outcomes might be selected as the outcome measure where for practical reasons (e.g. a relatively short study time horizon) you won't have information about final outcomes (e.g. life

2.2 Condition-Speci c and Generic Measures

Another choice between different types of potential benefit measure is between condition specific and generic measures of benefit.

Condition-specific benefit measures are measures that are specific to the particular illness category that we are concerned with. For example, in the condition of psoriasis you might use the "Psoriasis Area Severity Index (PASI)" which is specific to psoriasis or the "Dermatology Life Quality Index (DLQI)" which is specific to dermatological conditions.

Generic measures can be used in multiple different illness groups. Examples of generic measures include life years gained or instruments such as the Short Form 36 (SF-36) which asks questions across a number of different dimensions of health.

Pros and Cons

One of the main advantages of using a generic measure over a condition-specific measure is that it enables comparisons between different illness categories (e.g. we can compare life years gained across a range of interventions in oncology and cardiology.) However, the disadvantage of generic measures is that they tend not to be as sensitive in measuring benefits as the illness-specific measures. The choice between generic and condition specific measures may represent a trade-off of more transferability for sensitivity. The type and purpose of the economic evaluation you are undertaking may influence your choice of one over the other.

2.3 QALYs

For many health economists, Quality Adjusted Life Years (QALYs) are the preferred measure of health benefit to use in health economic evaluations.

The QALY is a measure of health related quality of life preferences that is generally measured on a scale of 0-1, with zero anchored at the value of death and one being the value placed on perfect health. It is however possible to have QALY values that are less than zero, with such negative values representing health states that are considered to be worse than death.

QALYs have many attractive features, not least that they provide one metric that captures three important dimensions:

- Time (e.g. time spent in health state(s), total life years gained)
- Health state(s) experienced
- Preferences relating to health state(s) experienced

QALYs aim to take a comprehensive view of health related quality of life and as a generic measure of health benefit allow for comparisons across illness groups. However, there are some disadvantages to using QALYs as well. For some conditions, QALYs may not be adequately sensitive to identify all of the relevant changes in a health state. More notably, as there are multiple methods to derive QALYs, care must be exercised before comparing results from different studies even when all results are measured in QALYs (which has been referred to as the *Is a QALY always a QALY*? question).

There are also a number of value judgments to consider. For example, is a health gain of a quarter of a QALY of equal value regardless of who experiences it or should we weight certain people's experience of a health improvement differently? One of the arguments for making such distinctions is at the end of life; is it legitimate for us to weight QALYs gained at that point more heavily than at other points in life because such gains provide individuals with a chance to address some really important things for both themselves and their families. There are also discussions about whether age weightings should be applied in order to capture some of the productivity benefits of health gains to individuals of working age. Some of these issues are explored in papers in the optional reading list.

Measuring and valuing QALYs

When it comes to measuring and deriving QALYs, we have to go through a number of steps:

Measuring health state

The first step is to get a description of the overall health an individual is experiencing at a specified point in time: i.e. what is their health today? There are a number of different types of instruments that can be used to measure overall health including the EQ-5D, SF-6D, HUI-3 and AQoL-8D (and the CHU-9D when measuring health states in children). These instruments ask patients questions across a number of dimensions of their health such as pain, psychological distress, mobility, self care, etc. in order to capture what the patients' or the individual's overall health is at this particular moment in time.

02

Apply preference weights to each health state

Having described the health state(s) experienced by a patient, the next step is to value that health state by applying preference weights. These preference weights will normally have been previously determined by a representative sample of the population whose perspective we are using to value the health states (e.g. members of the society in which the economic evaluation is occurring). As such, we are normally able to look up—or more likely have the software we are using look up—the appropriate preference weight from a list of preference weights for every potential health state described by the instrument we have chosen to measure health states.

03

Multiply preference weight

Multiply preference weight for each health state by the time spent in that health state. If a

patient spends a full year in a health state that is valued with a preference weight of 0.5, then we multiply 1 by 0.5 to get a total of 0.5 QALYs for the year that the patient spent in that health state.

04

Repeat steps 1-3

Repeat steps 1–3 for each distinct health state a patient experiences in the time period of interest and sum results. It is likely that over a period of time a patient will experience a number of health states. To use another simple example, imagine we have a time horizon of one year and a patient spends six months in a health state with a preferce weighting of 0.8 and six months with a preference weighting of 0.7. To calculate the QALYs experienced by this patient that year we would use:

0.5*0.8+0.5+0.7 = 0.4+0.35 = 0.75 QALYs

QALYs vs DALYs

A popular alternative to QALYs are DALYs (Disability Adjusted Life Years). There are a number of distinctions between QALYs and DALYs, most obviously represented by them using scales that are the inverse of each other; the DALY weighting for death is 1, for the QALY it is zero. The weights attached to different health states and the approach to age adjustments and discounting are also distinguishing features between the two measures. The Gold and Sassi papers from the recommended reading list discuss some of these issues further.

2.4 Valuation of Health States

When it comes to valuing health states (e.g. to develop the preference weights that are used in deriving QALYs), there are three commonly used valuation techniques that are administered to a sample of individuals from the population of interest (e.g. a representative sample of members of society). These three techniques are:

- Visual Analogue Scale (VAS)/Rating Scale (RS)
- Time Trade Off (TTO)
- Standard Gamble (SG)

Visual Analog Scale (VAS) / Rating Scale (RS)

In the Visual Analogue Scale (VAS) or Rating Scale (RS) method, participants are asked to rate the value that best represents the health state to them by marking a point on a thermometer like line between two anchor points (worst possible health/death to best possible health/perfect health).

VAS has the advantages of being very easy to administer and very simple for participants to understand. However, economists tend to prefer choice-based measures and measures that capture uncertainty. The disadvantages of the VAS are that it provides neither of these features.

Time Trade-off (TTO)

In the Time Trade-off (TTO) methods, participants choose a specified life expectancy in the health state being valued (less than perfect health) or a shorter life expectancy in perfect health. For example:

- *Which would you prefer: To live for another five years in the health state that has been described to you or to live for another four years in perfect health?*

This question will be repeated, but with different values for the life expectancy in each state. What we are looking for is the point at which an individual is unable to express a firm preference between two options. For example:

- When an individual is indifferent between five years of life expectancy in a particular health state and four years in perfect health, that would indicate that the preference weight for that health state is 0.8 (=4/5)

TTO is a choice-based method, which is an advantage but does not capture uncertainty which is a drawback. It is also not as simple to administer as the VAS.

Standard Gamble (SG)

The Standard Gamble (SG) shares some features with TTO, but instead of a measure of time, we have a measure of risk. Participants choose between a certain outcome of remaining in the health state of interest or taking a gamble with potential outcomes of perfect health and death. For example:

- *Which would you prefer: Remain in the health state that has been described to you or opt for a treatment with an 80% chance of recovery to full health and a 20% chance of death?*

As with TTO, we ask this question a number of different times, varying the probabilities each time. Our aim is to identify the point of indifference between the two options, which we can use to value the health state:

- If indifferent between certainty of health state and 80% chance of perfect health (and 20% chance of death), health state utility is 0.8 (=0.8*1+0.2*0)

SG has the significant benefits of being a choice-based method and incorporating uncertainty. However, in addition to being less straightforward to administer than the VAS, questions that involve the assessment of risk are frequently identified as more difficult for participants to understand.

3. Time Horizon and Time Preferences

As with the Analysis of Costs, there are pros and cons of short and longer time horizons in the Analysis of Benefits. These are:

- Time horizon
- Time preferences

3.1 Time Horizon

Recap on the pros and cons of short and longer time horizons.

- It is easier to measure outcomes and to measure them accurately over a relative short time. However, the downside of shorter time horizons is that we might miss out on important information relating to downstream outcomes that don't become apparent until maybe one year or two years after a particular decision has been made.
- Longer term horizons may be appropriate for projects with enduring or delayed cost and benefit impacts, but collecting this information may involve more expense and it may be difficult to actually acquire reliable outcome data over the longer time (e.g. losing contact with study participants).

3.2 Time Preferences (Discounting)

Our preferences for pleasure today and pain tomorrow also needs to be factored into our analysis of benefits on the basis that:

- a health improvement experienced for the next twelve months is generally more preferable to the same amount of health gain that we are due to experience in ten years time. For example, we might die in the interim and never get to experience the health gain.

If the study time horizon extends beyond one year, we must **discount** the future costs and benefits to account for the value of time preferences. We use a **discount rate** to adjust for time preferences between years. The economic evaluation guidelines for your country or region will frequently specify a discount rate for benefits. Note the discount rate for benefits may be different from that used for costs.

We have a choice of two main discounting formulae to use:

- If we are discounting a health gain at one time point (e.g. 0.8 QALYS for Year 5) we use:
    - PV=FV/(1+i)n
- If we are discounting a stream of health outcomes (e.g. 0.7 QALYs in Year 1, 0.8 QALYS in Year 2.....0.75 QALYs in Year 5) then we use:
    - PV=FV1/(1+i)1 + FV2/(1+i)2 + ...+FVn/(1+i)n
- In both cases, PV=Present Value, FV=Future Value, i=discount rate, n=year

Undertake the Analysis of Benefits Self-Assessment Exercise for an opportunity to apply these formulae in practice. Note, when using the above formulae, the current year is year zero.

Exercises and Further Reading

Self-assessment and critical review exercises

After reviewing this module's content:

1. Undertake the following critical review task:

- Review the descriptions of how benefits have been examined in the economic evaluation sample papers assigned to you (most likely to be found as part of the Methods section of each paper). See if you can identify what was the summary measure of benefit, how benefits were measured and valued, and what approach to discounting benefits has been used.

PDF

Health Economics Sample Economic Evaluation Paper 1.pdf

320.2 KB

PDF

Health Economics Sample Economic Evaluation Paper 2.pdf

346.6 KB

2. Undertake the following self-assessment task:

- **Self-Assessment Exercise 2: Analysis of Benefits**

In this self-assessment exercise, you will undertake the following tasks:

1) Place utility weights on health states.

2) Apply duration spent in health states to utility values to calculate undiscounted QALYs.

3) Discount QALYs.

All these tasks are to be completed using the Excel template labelled Self Assessment Exercise 2. You can complete your work by going through the worksheets labelled Q1 to Q3 in order, reviewing the task instructions on each worksheet and filling in the green cells. As you complete each worksheet's set of tasks, the information on subsequent worksheets will update.

When completed you can compare your results to the sample answer.

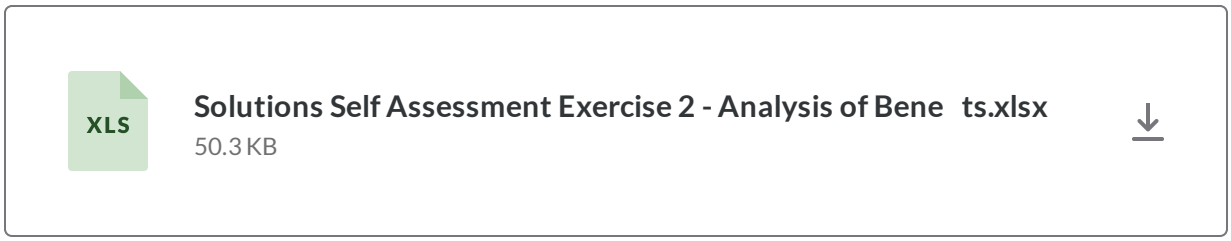
XLS

Self Assessment Exercise 2 - Analysis of Bene ts.xlsx

49.2 KB

EuroQol Crosswalk Value Set - Use for Self Assessment Exercise 2

Access and download EuroQol Crosswalk Value Set - by clicking this link.



References and Further Optional Reading

If you would like to do further optional reading about the topic, you may wish to consider the following resources:

- M Gold, D Stevenson and D Fryback. "HALYs and QALYs and DALYs, oh my: Similarities and Differences in Summary Measures of Population Health." 2002, Annual Review of Public Health
- National Institute for Health and Care Excellence (UK). "Consultation Paper: Value Based Assessment for Health Technologies". 2014, National Institute for Health and Care Excellence (UK).
- E Nord, N Daniels and M Kamlet. "QALYs: Some challenges" 2009, Value in Health.
- J Richardson and M Khan. "Do utility weights improve the predictive power of multi-attribute utilitity (MAU) instruments?" 2012 (revised 2014), Centre for Health Economics, Monash University.
- F Sassi. "Calculating QALYs, comparing QALY and DALY calculations." 2006, Health Policy and Planning.
- A Wailoo, S Davis and J Tosh. "The incorporation of health benefits in cost-utility analysis using the EQ-5D." 2010, Decision Support Unit, School of Health and Related Research, University of Sheffield.
- M Weintein, G Torrence, A Maguire. "QALYs: The basics" 2006, Value in Health.

Note on links: If you find that a hyperlink used in this module is out of date, please notify us at cdneducationlead@leadingedgegroup.com. You may also be able to find an out of date web resource by searching for the expired URL at http://archive.org/web/web.php.

Synthesis of Costs and Bene ts

Welcome to Unit Three of Module Two, which is: Synthesis of Costs and Benefits.

Unit Objectives

The goals of this unit are to:

- Describe and distinguish partial and full economic evaluations
- Introduce the key concepts of:
  - willingness to pay (WTP)
  - incremental cost-effectiveness ratio (ICER)
  - net benefit (NB)
  - dominance
  - cost-effectiveness plane

Unit Topics

There are two topics covered in this unit:

1. Partial Economic Evaluations

- Cost Consequence Analysis (CCA)

- Cost Minimization Analysis (CMA)

2. Full Economic Evaluations

- Cost-Benefit Analysis (CBA)
- Cost-Effectiveness Analysis (CEA)
- Cost-Utility Analysis (CUA)

Video Presentation

Here's the video presentation for this unit:

Video presentation notes:

1. Partial Economic Evaluations

Partial economic evaluations are distinguished by the fact that they don't fully synthesize costs and benefits in the form of a summary statistic. The two types of partial economic evaluations we are going to look at are **cost consequence analysis** and **cost minimization analysis.**

Cost Consequence Analysis (CCA)

Cost consequence analysis prepares a descriptive list of the costs and the range of consequences of a particular intervention. The analysis does not incorporate a method for trading off costs and benefits. Instead, it is left up to the decision-maker to look at the costs, look at the description of the consequences, and then make his or her own judgment as to whether or not the intervention represents value for money.

Cost Minimization Analysis (CMA)

Cost Minimization Analysis looks purely at costs and does not examine benefits at all. Where CMA is most useful is in cases where there are strong grounds to assume that the outcomes for a particular set of choices will be equivalent. In these circumstances, it is appropriate to put outcomes to one side and only focus on costs. Cost Minimization Analysis is often undertaken when an initial attempt to carry out a full economic evaluation, such as a Cost-Effectiveness Analysis or Cost-Utility Analysis, finds no statistically significant differences in outcomes between the options we are evaluating. Such a finding of equivalent outcomes could result in us changing our evaluation type from the full economic evaluation that was originally planned to a cost minimization analysis.

Making It Real

No creative process is truly complete until it manifests a tangible reality. Whether your idea is an action or a physical creation, bringing it to life will likely involve the hard work of iteration, testing, and refinement.

Just be wary of perfectionism. Push yourself to share your creations with others. By maintaining an open stance, you'll be able to learn from their feedback. Consider their

responses new material that you can draw from the next time you're embarking on a creative endeavor.

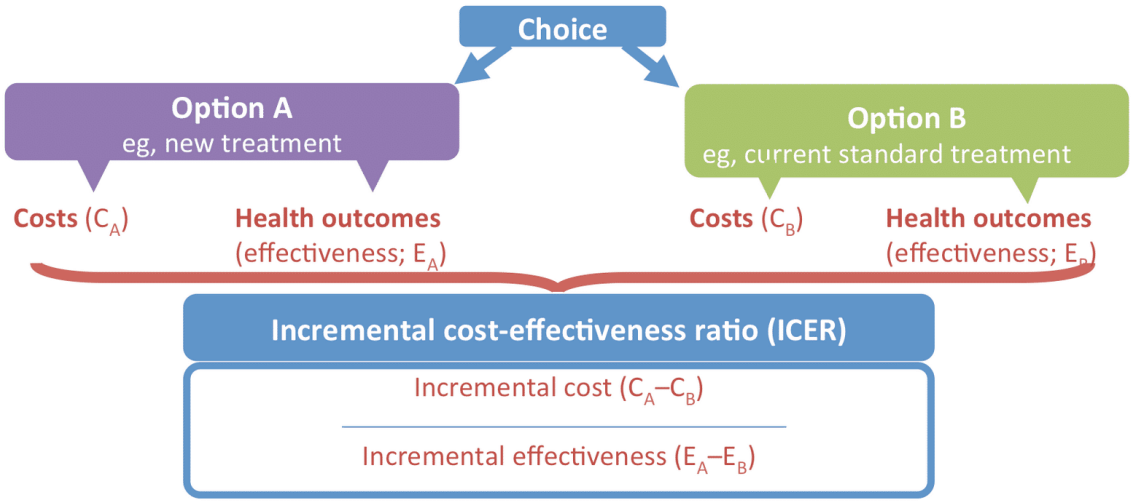
2. Full Economic Evaluations

There are three types of full economic evaluations:

- [ ] Cost Benefit Analysis
- [ ] Cost Effectiveness Analysis
- [ ] Cost Utility Analysis

2.1 Cost-Effectiveness and Cost-Utility Analyses

Cost-Effectiveness Analysis (CEA) and Cost-Utility Analysis (CUA) are essentially the same technique, with one minor but important distinction. In both types of economic evaluation, we examine both costs and benefits in order to produce a ratio statistic of differences in cost to differences in benefit. This ratio statistic is called the Incremental Cost-Effectiveness Ratio (ICER) and is calculated as follows:

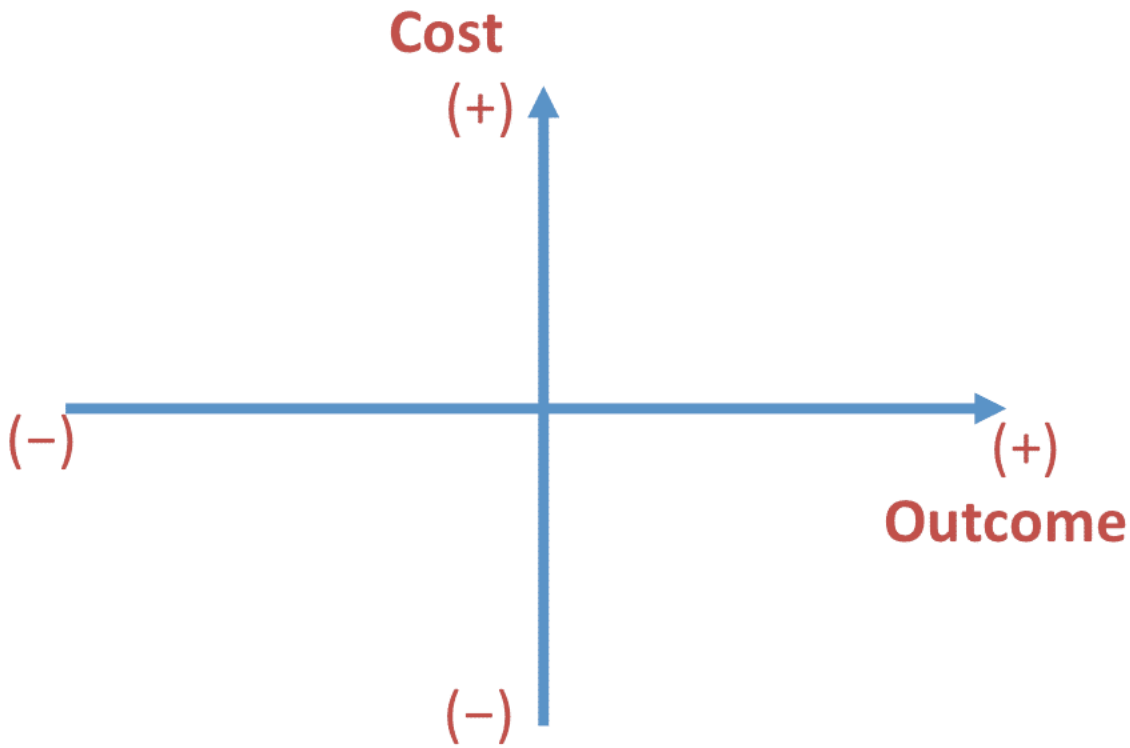


Bang H, et al. *J Stat Theory Pract*. 2012;6(3):428-442.

The only distinction between CEA and CUA is that the measure of benefit in cost-utility analysis, is a utility preference based measure (normally the QALY). In cost-effectiveness analysis, the unit of benefit can be any other type of measure - e.g. life years gained, improvements on a clinical scale, reductions in blood pressure, etc.

Once we have derived an ICER value for an intervention, we have to decide whether this ratio represents value for money. One of the easiest ways of determining this is actually plotting our results on a graph called the Cost-Effectiveness Plane.

The Cost-Effectiveness Plane



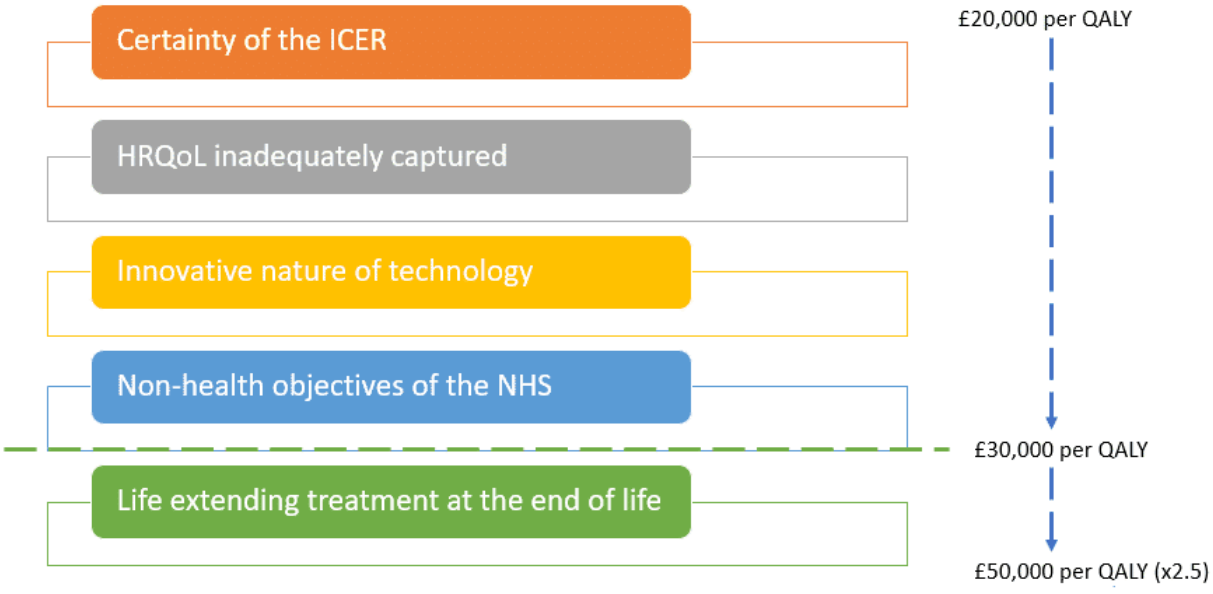
If our ICER result can be described as a point that lies in the top left or the bottom right quadrants of the Cost-Effectiveness Plane then our decision is really straightforward. A result in the bottom right quadrant means the intervention is more effective and less costly than its comparator, while a result in the top left quadrant means the intervention is both less effective and more costly than the comparator. In these circumstances, judgments about value for money are easy and the language we use for results in those quadrants is dominance.

- If something is more effective and less costly it is said to **dominate** the alternative
- If it is less effective and more expensive it is said to **be dominated** by the alternative

However, where things get a little bit more tricky is when our ICER result lies in the other two quadrants. Either we are dealing with something that is both more effective but more expensive (top right quadrant) or alternatively something that isn't as effective but is less costly (in the bottom left quadrant). In order to interpret results in either of these two quadrants, we need to have a criteria as to how we are prepared to trade off costs and benefits. The criteria that we use is called the willingness to pay threshold (WTPT).

Willingness to pay is the maximum amount of money that a decision-maker is prepared to sacrifice in order to procure an outcome (normally a unit of health benefit). In the case of healthcare, the decision-maker is often the Government and outcomes are frequently measured in QALYS, so in many developed economies Governments have published guidance about the WTP value or range of WTP values that they view as appropriate for each QALY gained. Different countries will adopt different WTP thresholds, but in developed economies these often approximate to per capita gross domestic product (GDP).

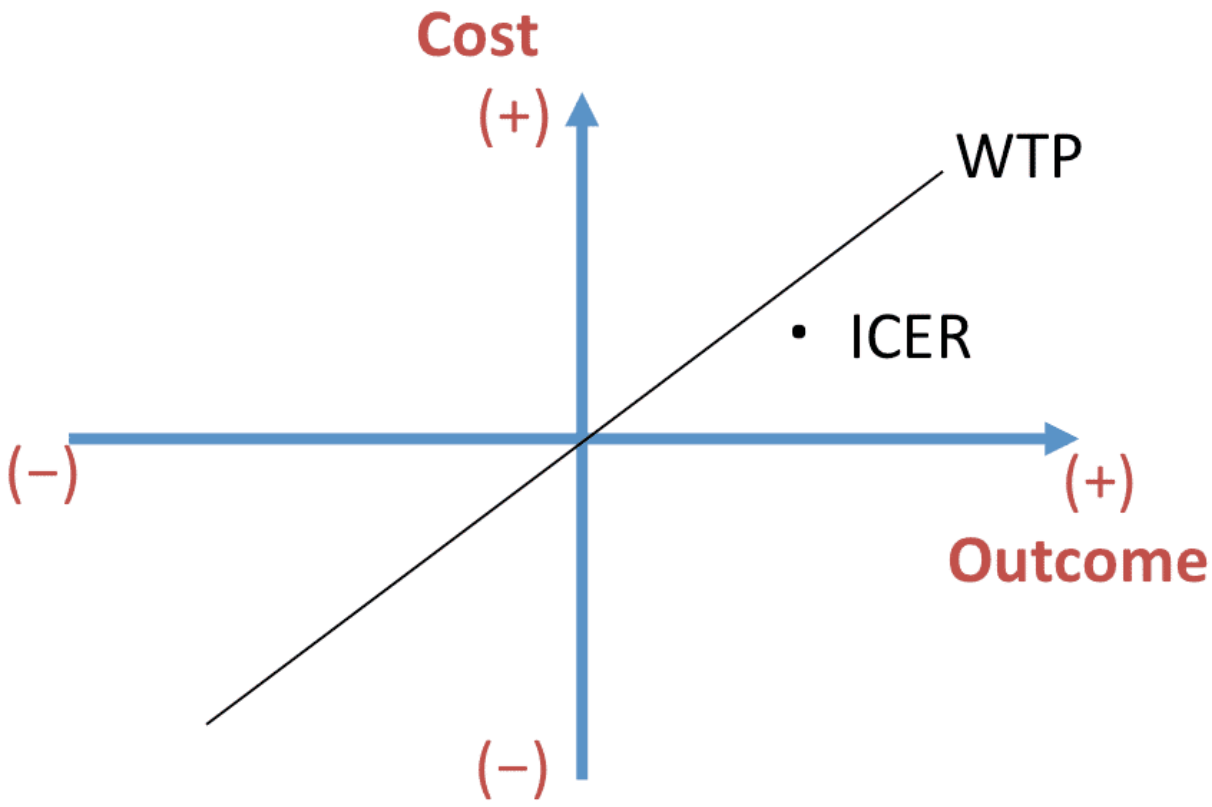
For example, in the United Kingdom the National Institute of Clinical and Health Care Excellence uses a threshold that normally lies between twenty to thirty thousand pounds sterling per QALY, a range which allows for a range of factors to be taken into account:



Source: National Institute of Health and Care Excellence, 2014.

The WTPT can be represented on the Cost-Effectiveness Plane as a straight line. Our decision rule for results in the top right or bottom left quadrants is simply whether our ICER result lies below or above the WTP line:

- An ICER that lies below the WTP line means the intervention is deemed to be cost-effective
- An ICER that lies above the WTP line means the intervention is deemed to not be cost-effective



In the above example, our ICER point lies below the WTP line in the top right quadrant indicating that at that willingness to pay value it can be judged to be cost-effective. In this instance, we can see that the decision-maker would be prepared to pay a little bit more for the

particular amount of health gain that is achieved per patient by the intervention being evaluated. So that's actually a really helpful way of determining whether or not something is cost-effective.

2.2 Cost-Bene t Analysis

- Cost-Benefit Analysis (CBA) is a full economic evaluation technique in which both costs and benefits are measured in monetary terms with results summarized in a Net Benefit (NB) statistic.
    - NB = Benefits - Costs

- The decision rule for cost-benefit analysis is: interventions with a net benefit of greater than zero are cost-effective. This makes sense when you consider that:

    - if Benefits>Cost, then NB >0
    - if Costs>Benefits, then NB <0
    - if Benefits=Costs, then NB=0

- Just as with CEA and CUA, willingness to pay values are an important part of cost-benefit analysis. In CBA, we use WTP values to convert all of the benefits that we are valuing into monetary measures. One of the advantages of CBA is that it allows us to combine multiple types of benefits within the one analysis. For example, we might choose to value benefits than include health outcomes (e.g. measured in QALYs) and patient satisfaction measures (measured on a service satisfaction scale). We would use different WTP values for each measure to convert each into monetary terms and sum them together for an overall monetary measure of benefits.

  When deriving WTP values, our main choices are to use revealed preference or stated preference techniques:

    - Revealed preference techniques involve the analysis of people's real world behaviors. Examples of revealed preferences are consumption decisions, decisions

relating to the salary premium that people demand for jobs with a higher risk of injury/death, and the travel time individuals expend in order to avail themselves of an amenity or service.

    - Stated preferences are used when it is not feasible to analyze how people actually behave. Instead, we ask people to declare their preference through techniques such as Discrete Choice Experiments and Contingent Valuation.

- Although CBA has some advantages over CEA and CUA in a healthcare system with a fixed budget, CUA will normally provide the key information that is relevant to healthcare priority-setting and may be more straightforward to undertake. For these reasons, CUA tends to be a lot more common than CBA in health economic evaluation.

Exercises and Further Reading

Self-assessment and critical review exercises

After reviewing this module's content:

1. Undertake the following critical review task:

- Review the descriptions of how costs and benefits have been synthesized in the economic evaluation sample papers assigned to you (most likely to be found as part of the Results section of each paper). See if you can identify the type of economic evaluation undertaken, the willingness to pay threshold used to interpret results (if any) and whether any of the following have been reported ICERs, Net Benefits, and Cost-Effectiveness Plane.

Health Economics Sample Economic Evaluation Paper 1.pdf
320.2 KB

PDF

Health Economics Sample Economic Evaluation Paper 2.pdf

346.6 KB

2. Undertake the following self-assessment task:

- **Self-Assessment Exercise 3: Synthesis of Benefits**

You have been provided with three partially completed Excel sheets with data from 100 hypothetical patients.

Your task is to:

1. Analyze Benefits (complete missing cells in first Excel sheet)

- Calculate mean benefits in intervention and control groups (hint - use AVERAGE command in Excel)
- Calculate Standard Deviation of benefits in intervention and control groups (hint - use STDEV command in Excel)
- Calculate the values between which 95% of intervention and 95% of control benefit results lie (hint - use PERCENTILE command in Excel)
- Calculate differences between intervention and control benefit results for each patient
- Calculate mean incremental effect between intervention and control groups
- Calculate the values between which 95% of incremental effects lie

2. Analyze Costs (complete missing cells in second Excel sheet)

- Calculate mean costs in intervention and control groups

- Calculate Standard Deviation of costs in intervention and control groups
- Calculate the values between which 95% of intervention and 95% of control cost results lie
- Calculate differences between intervention and control cost results for each patient
- Calculate mean incremental cost between intervention and control groups
- Calculate the values between which 95% of incremental costs lie

3. Synthesize Costs and Benefits (complete missing cells in third Excel sheet)

- Copy the benefit results from the first Excel sheet into the dark orange (intervention) and light orange (control) cells on the Study Sample - Effects worksheet
- Copy the cost results from the second Excel sheet into the dark orange (intervention) and light orange (control) cells on the Study Sample - Costs worksheet
- Calculate the point estimate for the Incremental Cost-Effectiveness Ratio on the worksheet called Summary Statistics
- Go to the Cost-Effectiveness Plane worksheet to see where your ICER result is plotted

Self Assessment Exercise 3 - Synthesis of Costs and Bene ts Part 1.xlsx

6.2 MB

Self Assessment Exercise 3 - Synthesis of Costs and Bene ts Part 2.xlsx

33.1 KB

XLS

Self Assessment Exercise 3 - Synthesis of Costs and Bene ts Part 3.xlsx

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Solution Self Assessment Exercise 3 - Synthesis of Costs and Bene ts Part 1.xlsx

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Solution Self Assessment Exercise 3 - Synthesis of Costs and Bene ts Part 2.xlsx

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Solution Self Assessment Exercise 3 - Synthesis of Costs and Bene ts Part 3.xlsx

6.2 MB

References and Further Optional Reading

If you would like to do further optional reading about the topic, you may wish to consider the following resources:

- K Claxton, S Martin , M Soares, N Rice, E Spackman, S Hinde, N Devlin, PC Smith, M Sculpher. "Methods for the estimation of the NICE cost effectiveness threshold." 2015,

Health Technology Assessment. [NOTE: LARGE FILE: Alternatively click on this link.]

- D Cohen and M Reynolds. "Interpreting the results of cost-effectiveness studies." 2008, Journal of American College of Cardiology.
- K Nimdet, N Chaiyakunapruk , K Vichansavakul, S Ngorsuraches. "A systematic review of studies eliciting willingness to pay oper Quality Adjusted Life Year: Does it justify CE threshold?" 2015, PLOS One.
- C Phillips. "What is cost-effectiveness?" 2009, Hayward Medical Communications.

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Uncertainty

Welcome to the Unit Four of Module Two, which is Uncertainty.

Unit Objectives

By the end of this unit, you should be able to meet the following objectives:

- identify sources of uncertainty
- outline a number of approaches to describing uncertainty
- identify strategies for addressing uncertainty

Unit Topics

This unit has three topics:

1. Sources of uncertainty

2. Describing uncertainty

3. Addressing uncertainty

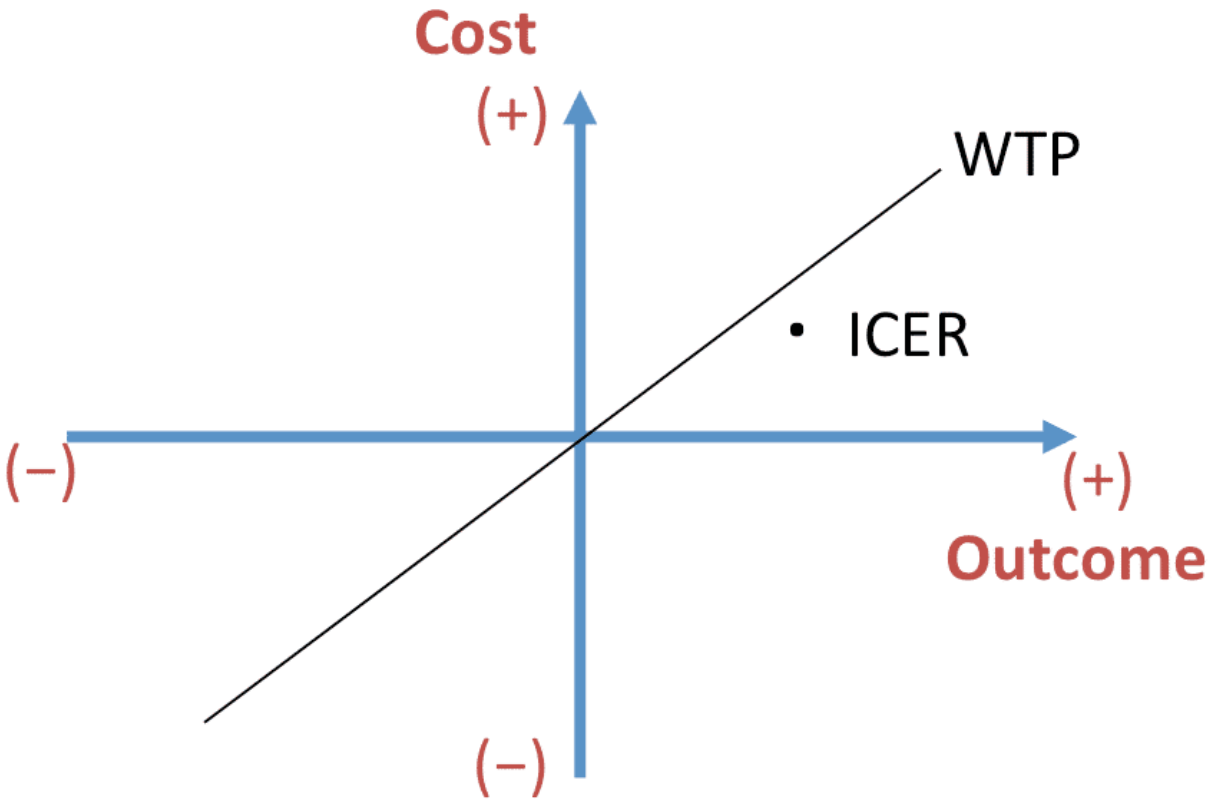
Video Presentation

Here's the video presentation for this unit:

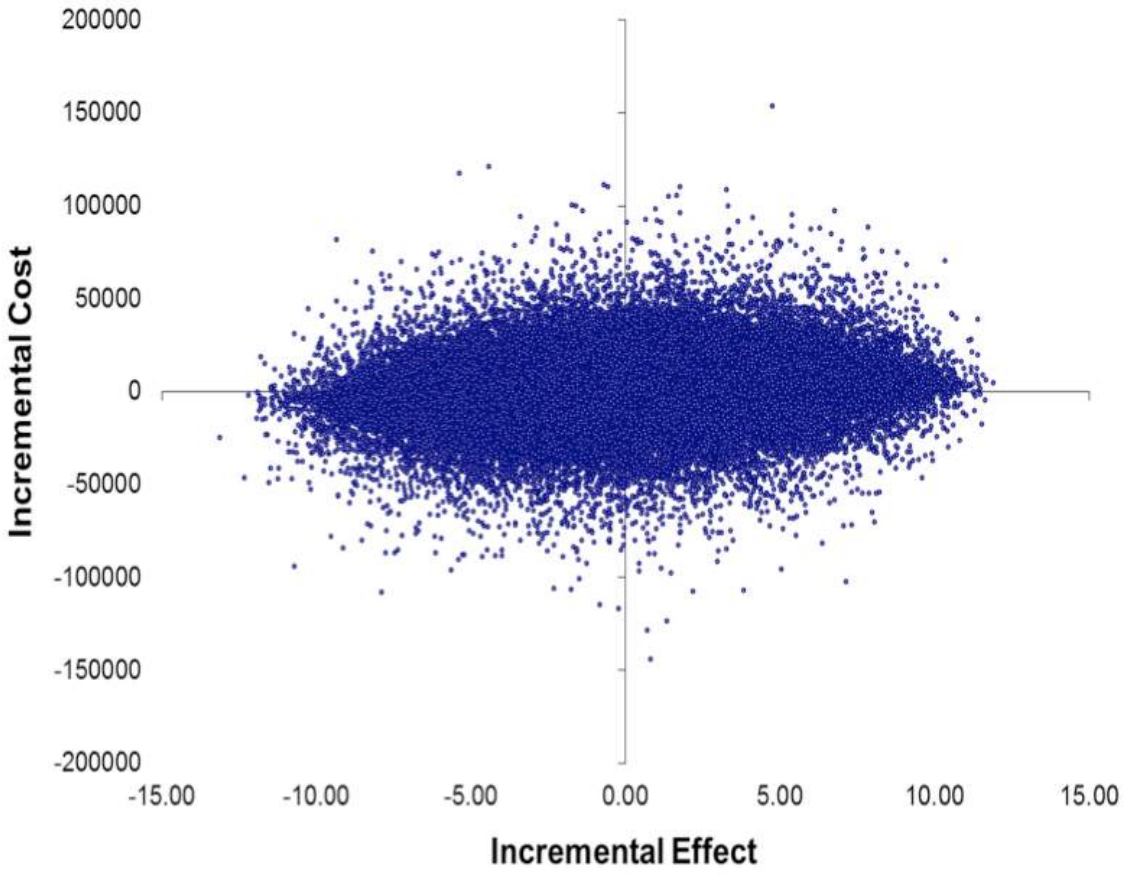
Video presentation notes:

1. Sources of Uncertainty

In the last unit, we outlined how the Cost-Effectiveness Plane could be used to plot an ICER value and the WTP threshold in a manner that provided us with a clear decision about the cost-effectiveness of an intervention:



However, when summarizing results from a cost-effectiveness or cost-utility analysis, we might actually end up with a plot that looks something like this:



The above Cost-Effectiveness Plane plots a total of 100,000 cost and effect pairs (i.e. the incremental cost and incremental effect results from 100,000 samples). As can be seen from this graph, results can vary significantly from sample to sample. If we plotted the WTP threshold line on the above chart, we would find that large proportions of cost-and-effect pairs lay either side of the line. This means that whether the intervention is actually cost-effective or not may depend on a number of uncertain factors such as the characteristics of the patients in each sample.

We can simplify this chart by getting the mean value of the incremental cost results for all the 100,000 samples and the mean value of all the incremental effect results from all 100,000 samples in order to plot a single ICER point estimate (the ratio of mean incremental costs and mean incremental effects for all samples) on the CE Plane and see if it falls below the WTP

threshold line. Although such an approach is useful (and if we had to make a decision now, using the single ICER point would give us the best answer on the basis of the evidence currently available) on its own it may provide a misleading sense of certainty about the results.

For example, the plot of the 100,000 results indicates that there is no strong evidence of either alternative being more cost-effective than the other. Regardless of whether an ICER based on mean incremental cost and mean incremental effect is above or below the WTP line, we could not feel confident about making a recommendation because we know that a very high proportion of samples produced a different result. In the case of such an uncertain result, unless we are obliged to make a decision immediately, we would ideally want to undertake further analysis before making a recommendation. One of our initial priorities would be to try and understand why the results are so uncertain and what we could do to potentially reduce that uncertainty.

Evidence sources

In exploring the potential sources of uncertainty, we may wish to start by examining the evidence source for our results. In particular, we may wish to reassure ourselves that the study from which we are drawing our results has both internal and external validity:

Internal validity

Internal validity is the extent to which the design and conduct of the study has eliminated potential sources of bias so that the study is able to adequately address the specific research question it is aiming to answer.

Gaining Insight

External validity is the extent to which evidence from a study can be generalized. For example, is it reasonable to believe that results from the study be applied to different

populations/settings?

Heterogeneity and Stochastic Uncertainty

Another distinction that we should attempt to understand is the extent to which uncertainty may be due to **heterogeneity** or **stochastic** uncertainty.

Heterogeneity

Cost and benefit outcomes may vary between individuals based on the characteristics of those individuals (e.g. variations arising from age, gender, ethnicity, socio-economic status). This means that it may be possible to explain some of the uncertainty in a set of results by understanding how results vary by different population subgroups.

Stochastic

Even for identical individuals, outcomes may vary based on "luck of the draw." Two identical patients receiving identical treatments may have different outcomes, just as the same coin tossed twice may land on heads the first throw and tails the second.

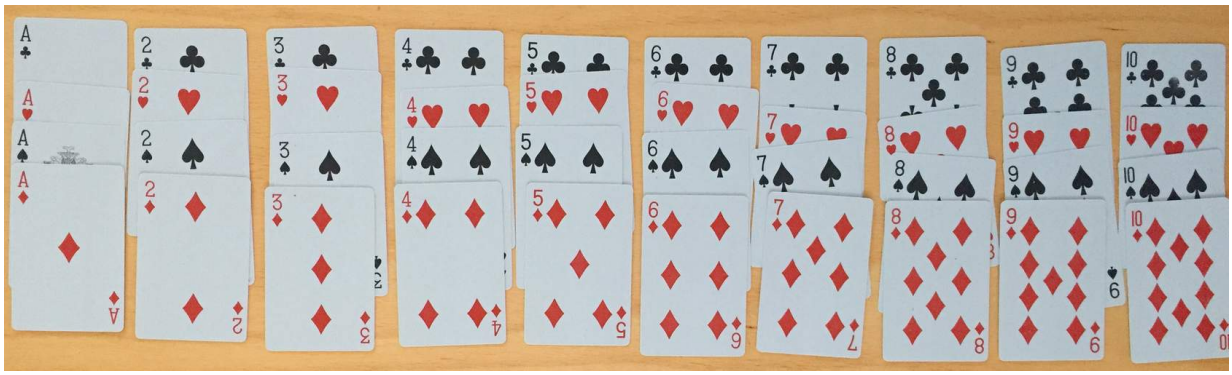
2. Describing Uncertainty

There are a number of ways we can describe uncertainty in health economic evaluations, including:

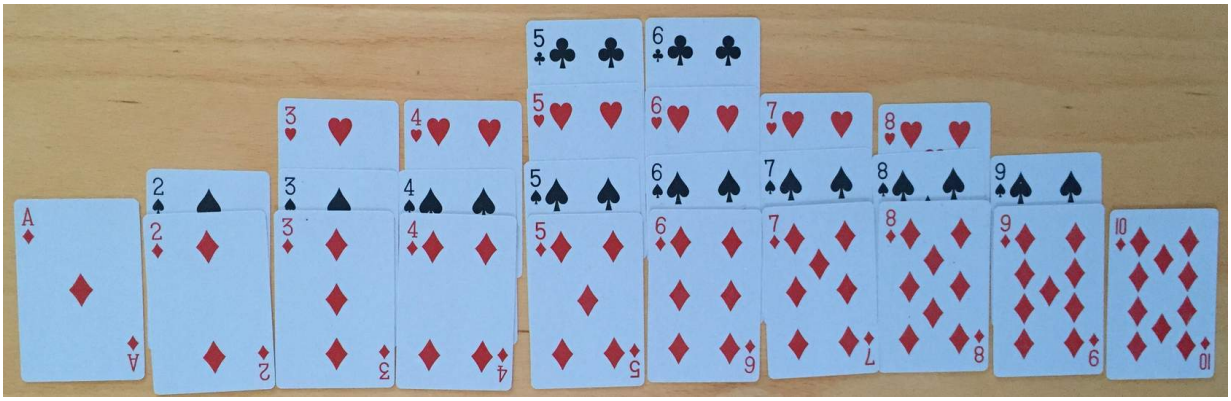
- [ ] distributions
- [ ] confidence intervals and standard errors
- [ ] cost-effectiveness acceptability curves

Distributions

One way to think about distributions is to think of a deck of playing cards. If we lay out all the cards in ascending order, we can see the distribution of number cards throughout the deck. If we do this immediately after opening a new deck, we will see that there are equal amounts of each number card (meaning that if the deck is fairly shuffled there is the same probability of drawing each number card). This is called a uniform distribution.



If we take away a number of cards (taking away relatively more cards at lower and higher numbers and taking away zero cards for middle values), our distribution changes to something resembling a normal distribution. If these remaining cards are shuffled, we are now more likely to draw a 5 or a 6 than an Ace or a 10. Normal distributions (and log normal distrubutions, which adhere to the same basic bell shape) are useful for describing the frequencies with which many health and biological phenomena occur.



There are other ways that we could have removed cards to leave cards that described a range of alternative distributions. Different types of data will tend to be described by different types of distributions. For example:

- [ ] Gamma distributions are frequently used to describe cost data
- [ ] Poisson distributions are used for binary/count data (e.g. number of times a coin landed on heads)
- [ ] Beta distributions are bounded between 0 and 1 and are frequently used for utility measures
- [ ] Exponential distributions are used for rates at which events occur (where the rate does not change over time)
- [ ] Weibull distributions are used for rates that change over time

Confidence intervals and standard errors

Health economic evaluations frequently describe uncertainty by using **confidence intervals** and **standard errors**.

Con dence interval

A confidence interval refers to a range of values within which we can have a set level of confidence that the value of a parameter lies. A 95% confidence interval of (1.5, 3.5) means we are 95% confident that the value of the parameter of interest is somewhere between 1.5 and 3.5

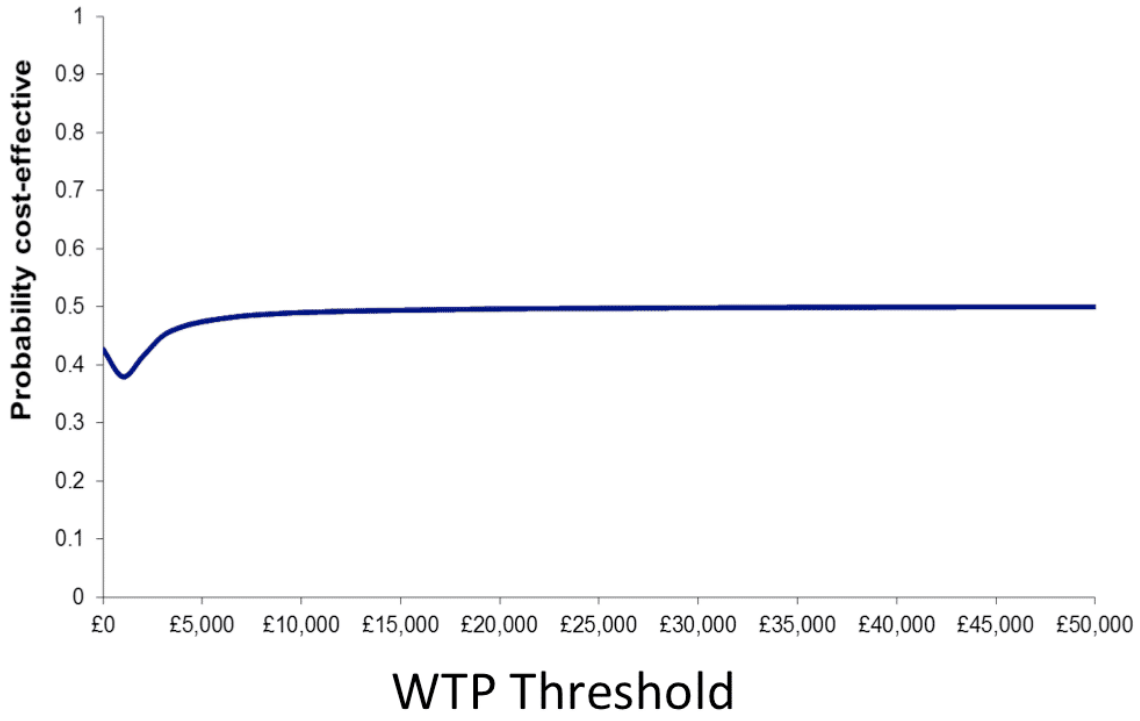
Standard errors

Standard error is a measure of the precision of an estimated mean value. Formally, it is defined as the standard deviation of the sampling distribution of the sample mean. Standard errors should not be confused with standard deviations, which describe the dispersion of a sample, not the accuracy of the estimate.

Cost-Effectiveness Acceptability Curves (CEACs)

Another potential source of uncertainty in economic evaluation results relates to the value of the WTP threshold. If the most appropriate value for the WTP threshold is different to the one we used to calculate our results (i.e. the WTP threshold line should have been either more or less steep than the one we drew on the Cost-Effectiveness Plane), then our decision about the cost-effectiveness of the intervention may be wrong.

A method that aims to describe the uncertainty relating to the WTP threshold is the Cost-Effectiveness Acceptability Curve (CEAC). The CEAC plots the probability that an intervention is cost effective at a range of potential WTP values. The example below relates to the same 100,000 pairs plotted on the CEAC in the previous section. That is why no matter what the WTP threshold is, the results remain close to 50%.



3. Addressing Uncertainty

Most economic evaluation papers have a section that explicitly explores some of the uncertainty of the results by conducting sensitivity analysis.

There are two main categories of sensitivity analysis:

Deterministic Sensitivity Analysis (DSA)

Deterministic Sensitivity Analysis (DSA): In DSA, the analysis is rerun (potentially a number of times) with changes to some of the values of individual parameters in order to see the impact

of alternative values for those parameters on overall results. An example would be to rerun an analysis for low, middle, and high values for the unit price of a medication used as part of the intervention.

Probabilistic Sensitivity Analysis (PSA)

Probabilistic Sensitivity Analysis (PSA): In PSA each parameter is assigned a distribution, and a new value for each parameter is drawn from the relevant distribution for each of a defined number of runs. For example, in each run a value is randomly picked for unit price of medication (from a defined range of possible values), for treatment effects (from another defined range) and for all other parameters.

Exercises and Further Reading

Self-assessment and critical review exercises

After reviewing this module's content:

1. Undertake the following critical review task:

- Review the descriptions of how uncertainty has been described and explored in the economic evaluation sample papers assigned to you (most likely to be found as part of the Results and Sensitivity Analysis sections of each paper). See if you can identify the manner in which uncertainty was described (whether different sources of uncertainty were identified, whether confidence intervals, distributions, and standard errors were used) and whether deterministic and/or probabilistic sensitivity analyses were used).

PDF

Health Economics Sample Economic Evaluation Paper 1.pdf

320.2 KB

PDF

Health Economics Sample Economic Evaluation Paper 2.pdf

346.6 KB

References and Further Optional Reading

If you would like to do further optional reading about the topic, you may wish to consider the following resources:

- R Baltussen, R Hutubessy, D Evans and C Murray. "Uncertainty in cost-effectiveness analysis: probabilistic uncertainty anayses and stochastic league tables." 2000, World Health Organisation.
- E Fenwick and S Byford "A guide to cost-effectiveness acceptability curves" 2005, British Journal of Psychiatry.
- S Griffin "Dealing with uncertainty in the economic evaluation of health care technologies" 2010, University of York.

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